Appendix H

Air quality and greenhouse gas assessment

REPORT

AIR QUALITY ASSESSMENT FOR ENERGYAUSTRALIA'S SYDNEY CITYGRID PROJECT INCLUDING GREENHOUSE GAS ASSESSMENT FOR THE BELMORE PARK ZONE SUBSTATION

PlanCom Consulting Pty Ltd

21 July 2008 Job 2587

PACIFIC AIR & ENVIRONMENT

PROJECT TITLE:	Air Quality Assessment for EnergyAustralia's Sydney Citygrid Project including Greenhouse Gas Assessment for the Belmore Park Zone Substation
JOB NUMBER:	2587
PREPARED FOR:	Julian Ardas PlanCom Consulting Pty Ltd
STATUS:	21 July 2008
PREPARED BY:	Matt Scholl & Kelsey Bawden
APPROVED FOR RELEASE BY:	Emmanuel Anglo
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REVISIONS:

VERSION	DATE	DESCRIPTION	PREPARED BY	REVIEWED BY
V1	21.05.08	DRAFT	M.SCHOLL	E.ANGLO
V2	21.07.08	DRAFT	K. BAWDEN	J. ARDAS
V3	21.07.08	DRAFT	K. BAWDEN	J. ARDAS

Queensland Environment Pty Ltd trading as
Pacific Air & Environment ABN 86 127 101 642

BRISBANE:
Level 1, La Melba, 59 Melbourne Street South Brisbane Qld 4101
PO Box 3306 South Brisbane Qld 4101
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

SYDNEY:
3 Spring Street Sydney NSW 2000
PO Box 4216 Sydney NSW 2001
Ph: +61 2 8249 4464
Fax: +61 2 8249 4001

Email: enquiries@pae.net.au
Website: www.pae.net.au

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ES1 EXECUTIVE SUMMARY

PlanCom Consulting Pty Ltd (PlanCom) engaged Pacific Air & Environment (PAE) to provide an air quality assessment for the Sydney CityGrid Project including a greenhouse gas assessment for the Belmore Park Zone Substation. The work has been commissioned by EnergyAustralia as part of the contract for "Environmental Planning & Assessment Services for the Sydney CityGrid Project".

To meet licence obligations, cater for future demand and ensure timely replacement of older infrastructure, EnergyAustralia wishes to carry out various and staged new construction works as well as upgrading and refurbishing of existing infrastructure and assets within the Sydney Central Business District (CBD) (the "Project").

The Project will be assessed by the NSW Department of Planning under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). It will broadly include the following works:

- construction of up to three zone substations (including, if necessary, the demolition and/or refurbishment of existing zone substations and integrated commercial developments constructed on or in conjunction with the zone substations);
- replacement of and upgrades to high voltage cable network; and
- construction of tunnels for the installation of high voltage cables and associated communications infrastructure.

The Project components and required timeframes for delivery are described in Table ES1.1.

Table ES1.1: Project Components and Required Timeframes for Delivery

Project Component	Required Timeframe for Delivery [a]
Extension to the existing City South Cable Tunnel from Wade Place to Riley Street, Surry Hills (approximately 150m)	Mid 2012
Stub tunnel connection from the existing City South Cable Tunnel (nominally 20m below Campbell Street) to Belmore Park Zone Substation	Mid 2012
Belmore Park Zone Substation, encompassing commercial/retail development (at the corner of Pitt, Hay and Campbell Streets	Mid 2012
City East Cable Tunnel (approximately 3.2km) from Riley Street, Surry Hills to Erskine Street, City North, inclusive of potential ventilation shaft and services at a midway point along the alignment	Mid 2015
City East Zone Substation, potentially encompassing commercial/retail development (at a site yet to be determined)	Mid 2015
New Sub-transmission Switching Station (STSS) at Riley Street, Surry Hills, and potentially a tunnel services control and access to the City East Cable Tunnel (in the alternative the control and access would be located at a midway point along the tunnel alignment)	Mid 2015
Potential refurbishment or replacement of the existing Dalley Street Zone Substation or building at a nearby site (including possible use of 183-185 Clarence Street as a switching station).	2018

[a] pers comm J. Ardas, PlanCom Consulting Pty Ltd, 28/05/2008

The objectives of this study are to consider the potential air quality impacts of the Project during construction and operation and assess whether mitigation is required. Where mitigation is required, appropriate measures are recommended. In addition, the greenhouse gas assessment is provided for the Belmore Park Zone Substation component of the Project.

Air quality was assessed based on an indicative construction activity plan and scheduling sequence, taking into account the location and the context of the surrounding area to determine the potential for exposure and or adverse impacts.

A review of construction equipment and vehicles and materials handling was conducted to identify emission sources from the works.

The main concern for air quality is the potential for emissions of dust and PM_{10} during construction. However, air quality impacts are predicted to be insignificant if best practice dust management procedures are practised. Mitigation measures were proposed to reduce emissions where possible and these recommendations could be included in a Construction Environmental Management Plan (CEMP) for the Project.

Potential for air quality impacts during operation of the Project have also been considered, however there are no predicted adverse impacts on air quality during the operation of the substations and high voltage tunnel.

Direct (Scope 1) greenhouse gas emissions are produced from sources within the boundary of an organisation and as a result of an organisation's activities. Scope 1 greenhouse gas emissions will be generated during construction of the Belmore Park Zone Substation from combustion engines of construction equipment.

During operation of the proposed Belmore Park Zone Substation there is potential for Scope 1 greenhouse gas emissions from leakage or spillage of insulating gas used in transformers and switchgear. These emissions will be minimised by adhering to industry best practice procedures for handling and disposal of the insulation gas, sulfur hexafluoride (SF_6).

Indirect greenhouse gas emissions (Scope 2 & 3) are generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation. The most important category of indirect emissions is from the consumption of electricity.

The greenhouse gas assessment only considers the Belmore Park Zone Substation. Scope 2 emissions from electricity consumption to operate the substation are addressed and emissions from Transmission and Distribution (T&D) losses will be reported by EnergyAustralia elsewhere.

Provided that the appropriate management and mitigation measures are followed the impacts on air quality from the Project and emissions of greenhouse gases from the Belmore Park Zone Substation are considered to be acceptable.

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Abbreviations and Glossary

Term	Definition
$\mu g/m^3$	Micrograms per cubic metre. A measure of particulate concentration in ambient air.
Air NEPM	National Environment Protection Measure for Ambient Air Quality
AIS	Insulation of air
CBD	Sydney Central Business District
CECT	Cross East Cable Tunnel
CEMP	Construction Environmental Management Plan
CO	Carbon monoxide
CO_{2-e}	Carbon dioxide equivalents
ENA	Energy Networks Australia
EP&A Act	NSW Department of Planning Environmental Planning and Assessment Act 1979
GIS	Insulation by SF6
GJ	Gigajoules or 1,000,000,000 Joules. A measure of energy.
GHG	Greenhouse gases i.e. carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, perfluorocarbons, hydrofluorocarbons.
GMR	Sydney Greater Metropolitan Region. Area that covers 57,330 km^2, which includes the greater Sydney, Newcastle and Wollongong regions.
GWP	Global warming potential relative to carbon dioxide over a 100 year period.
kg	Kilogram or 1,000 grams. A measure of mass.
kL	Kilolitres or 1,000 litres or cubic metre. A measure of volume.
kV	Kilovolts or 1,000 volts. A measure of the strength of an electrical source.
kWh	Kilowatt hours or 1,000 watt hours.
LCA	Life Cycle Assessment
m^2	Square metres. A measure of area.
m^3	Cubic metre or kilolitre or 1,000 litres. A measure of volume.
MVA	Megavolt amperes
n-2 licence conditions	Design, Reliability & Performance Licensing Conditions by the Minister for Energy for the Sydney CBD by 2014
NGA	National Greenhouse Accounts
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen i.e. nitric oxide (NO) and nitrogen dioxide (NO2)
NSW	New South Wales
NSW DECC	NSW Department of Environment and Climate Change
PAE	Pacific Air & Environment
PlanCom	PlanCom Consulting Pty Ltd
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 micrometres. Also referred to as fine particulate matter.
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5 micrometres.
ppm	Parts per million (mass basis)
Riley Street STSS	Riley Street Sub Transmission Switching Station
Roadheader	Mechanical excavating machines that have a large rotating cutting head mounted on a moveable boom. They are able to turn tight corners during tunnel construction.
Scope 1 greenhouse gas emissions	Direct emissions produced from sources owned or controlled by the entity.
Scope 2 greenhouse gas emissions	Indirect emissions from the generation of purchased electricity consumed by the entity.
Scope 3	Indirect emissions that are a consequence of the activities of an entity, but which arise

Term	Definition
greenhouse gas emissions	from sources not owned or controlled by that entity (with the exception of electricity generation).
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
STSS	A sub-transmission switching station – generally 132kV (without transformers)
Stub tunnel	A short section of tunnel which links to a main tunnel
t	Tonne or 1,000 kilograms. A measure of mass.
T&D	Transmission and Distribution
TBM	Tunnel Boring Machine
TEOM	Tapered-element oscillating microbalance. An instrument used to measure ambient concentrations of particulate matter.
TSP	Total suspended particulate

1 INTRODUCTION

PlanCom Consulting Pty Ltd (PlanCom) engaged Pacific Air & Environment (PAE) to provide an air quality assessment for the Sydney CityGrid Project including a greenhouse gas assessment for the Belmore Park Zone Substation. The work has been commissioned by EnergyAustralia as part of the contract for "Environmental Planning & Assessment Services for the Sydney CityGrid Project".

To meet licence obligations, cater for future demand and ensure timely replacement of older infrastructure, EnergyAustralia wishes to carry out various and staged new construction works as well as upgrading and refurbishing of existing infrastructure and assets within the Sydney Central Business District (CBD) (the "Project").

The Project will be assessed by the NSW Department of Planning under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act).

1.1 Project Summary

Peak electricity demand in the Sydney CBD is growing at an average rate of 1.7% per annum driven primarily by new residential, hotel and office developments.

EnergyAustralia, over the next 10 years, needs to construct new, or upgrade and refurbish existing, zone substations and replace high voltage cables supplying the substations in order to:

- Meet n-2 licence conditions;
- Cater for future demand and introduce new technologies that are likely to reduce electricity 'losses' by reducing the resistance of the electricity network; and
- Ensure timely replacement of infrastructure which is due for retirement to maintain a reliable supply of electricity for the CBD.

Building works would include the construction of up to three zone substations (including, if necessary, the demolition and/or refurbishment of existing zone substations and would most likely include integrated commercial/retail developments on or in conjunction with the zone substations). The Project also involves the construction of up to three new tunnel sections in the Sydney CBD, and the city fringes, which would 'link' the existing tunnel networks and key zone substations servicing the city together.

1.2 Project components

1.2.1 Sydney CityGrid Project Concept Application

New and/or refurbished substations in the Sydney CBD and a tunnel network for 132 kV cables comprising:

1. Extension to the existing City South Cable Tunnel from Wade Place to Riley Street, Surry Hills (approximately 150m);

2. Stub tunnel connection from the existing City South Cable Tunnel (nominally 20m below Campbell Street) to Belmore Park Zone Substation;

3. Belmore Park Zone Substation, encompassing commercial/retail development (at the corner of Pitt, Hay and Campbell Streets);

4. City East Cable Tunnel (approximately 3.2km) from Riley Street, Surry Hills to Erskine Street, City North, inclusive of potential ventilation shaft and services at a midway point along the alignment;

5. City East Zone Substation, potentially encompassing commercial/retail development (at a site yet to be determined);

6. New Sub-transmission Switching Station (STSS) at Riley Street, Surry Hills, and potentially a tunnel services control and access to the City East Cable Tunnel (in the alternative the control and access would be located at a midway point along the tunnel alignment); and

7. Potential refurbishment or replacement of the existing Dalley Street Zone Substation or building at a nearby site (including possible use of 183-185 Clarence Street as a switching station).

1.2.2 Belmore Park Zone Substation Project Application

1. Belmore Park Zone Substation, encompassing commercial/retail development (at the corner of Pitt, Hay and Campbell Streets); and

2. Stub tunnel connection from the existing City South Cable Tunnel (nominally 20m below Campbell Street) to Belmore Park Zone Substation.

Figure 1.1 provides an indicative plan showing the works for the proposed Project.

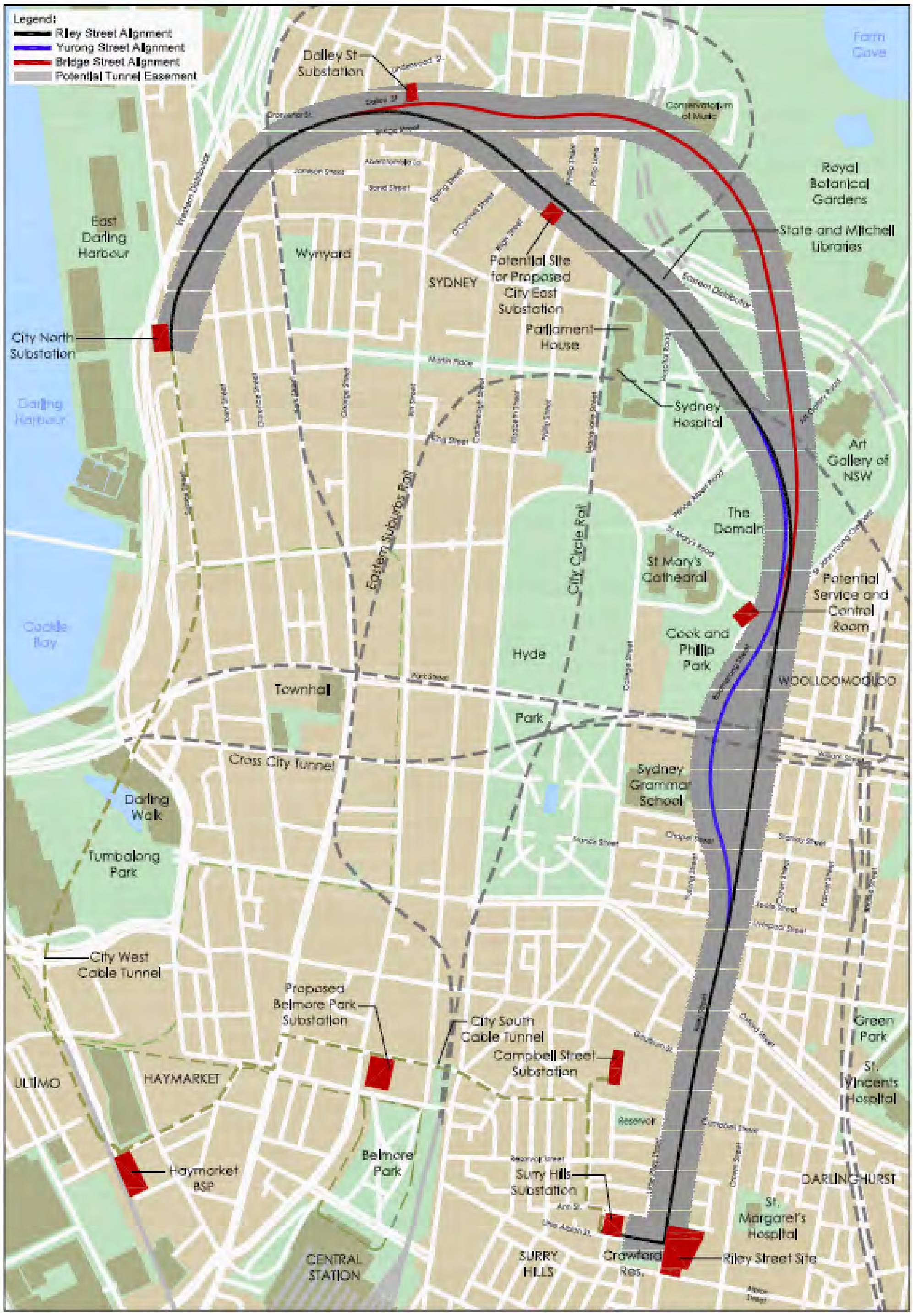

Figure 1.1: Indicative plan showing the works for the proposed Project

The Project components and required timeframes for delivery are described in Table 1.1.

Table 1.1: Project Components and Required Timeframes for Delivery

Project Component	Required Timeframe for Delivery [a]
Extension to the existing City South Cable Tunnel from Wade Place to Riley Street, Surry Hills (approximately 150m)	Mid 2012
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[a] pers comm J. Ardas, PlanCom Consulting Pty Ltd, 28/05/2008

1.3 Study Objectives

In terms of air quality the objectives of the study are to consider the potential impacts of the Project during construction and operation, including excavation works, construction of tunnels and demolition and/or construction or refurbishment of the substations and assess whether mitigation is required. Where mitigation is required then appropriate measures are recommended.

The objective of this study with respect to greenhouse gases is to assess emissions from the Belmore Park Zone Substation component of the Project during the construction and operation of the substation and the stub tunnel. Where information is not yet available in detail, a qualitative assessment is provided.

2 STUDY APPROACH

2.1 Air Quality

Air quality was assessed based on an indicative construction activity plan and scheduling sequence, taking into account the location and the context of the surrounding area to determine the potential for exposure and or adverse impacts.

A review of construction equipment and vehicles and materials handling was conducted to identify emission sources from the works.

Mitigation measures were proposed to reduce emissions where possible and these recommendations could be included in a Construction Environmental Management Plan (CEMP) for the Project.

Potential for air quality impacts during operation of the Project have also been considered.

2.2 Greenhouse Gases

Direct (Scope 1) greenhouse gas emissions are produced from sources within the boundary of an organisation and as a result of an organisation’s activities.

Scope 1 greenhouse gas emissions will be generated during construction of the Belmore Park Zone Substation from combustion engines of construction equipment.

During operation of the proposed Belmore Park Zone Substation there is potential for Scope 1 greenhouse gas emissions from leakage of insulating gas from transformers and switch gear.

Indirect greenhouse gas emissions (Scope 2 & 3) are generated in the wider economy as a consequence of an organisation’s activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation. The most important category of indirect emissions is from the consumption of electricity. Scope 2 emissions are allocated to the organisation that owns or controls the plant or equipment where the electricity is consumed. Usually, the electricity consumer reports only the emissions from the electricity they use under Scope 2, and reports emissions associated with transmission and distribution (T&D) losses under Scope 3. However, companies that own or control T&D networks, i.e. EnergyAustralia, report emissions associated with all T&D losses on their networks under Scope 2.

This assessment only considers the Belmore Park Zone Substation. Scope 2 emissions from electricity consumption to operate the substation are addressed and emissions from T&D losses will be reported by EnergyAustralia elsewhere.

Where activity data are available, emissions are assessed using emission factors outlined by the *National Greenhouse Accounts (NGA) Factors (2008)*, which are published by the Australian Government Department of Climate Change. Activity data were provided by EnergyAustralia.

3 EMISSIONS TO AIR

3.1 Sources of Emissions

There is potential for emissions of combustion gases and dust to be generated during demolition and construction works of the existing zone substations and integrated commercial developments as well as during excavation and tunnelling construction works and spoil handling activities.

During operation of the substation, there is potential for Scope 1 greenhouse gas emissions of sulfur hexafluoride (SF_6) to be released via leakage from gas insulated transformers and other switchgear and circuit breaker applications.

During operation of the substation, emissions from electricity used to power the substation are considered as indirect (Scope 2) greenhouse gas emissions.

3.2 Pollutants of Interest

The main pollutants of interest are total suspended particulates (TSP) and particulate matter less than 10 micrometres in aerodynamic diameter (PM_{10}) that may be emitted due to the proposed demolition and construction works.

Combustion emissions, i.e. oxides of nitrogen (NO_X), fine particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO) and sulfur dioxide (SO_2) from construction vehicles are also likely to be released.

During operation of the Belmore Park Zone Substation there is also potential for emissions of sulfur hexafluoride (SF_6) from gas insulated transformers and other switchgear and circuit breaker applications. SF_6 is a highly potent greenhouse gas. Its global warming potential (GWP) is 23,900, which means that over a 100-year period, SF_6 is 23,900 times more effective at trapping infrared radiation than an equivalent amount of carbon dioxide. With an atmospheric lifetime of 3,200 years, SF_6 is also a very stable chemical. Therefore, due to its long lifespan and high potency, even a relatively small amount of SF_6 can have a significant impact on global climate change.

Apart from its use as an insulating medium in the electricity transmission industry, SF_6 is also used as a cover gas in the magnesium industry, for plasma etching in semiconductor manufacturing, as a reactive gas in aluminium recycling to reduce porosity, as thermal and sound insulation and in atmospheric tracer studies and medical applications.

4 EXISTING AIR QUALITY

This section provides an overview of existing air quality in Sydney. These summaries for pollutants are from a technical paper provided by the NSW DECC, providing a review of air quality in NSW to support the Clean Air Forum 2007 (NSW DECC, 2007).

Air quality has been monitored in Sydney since the early 1950s. The NSW DECC operates a comprehensive state-wide air quality monitoring network comprising sites throughout NSW, with particular focus on the main population centres of Sydney, the lower Hunter and the Illawarra. The information provided below is based on monitoring data from that network.

4.1 Carbon monoxide

Carbon monoxide (CO) is currently monitored at five stations in the Sydney region (Chullora, Liverpool, Macarthur, Prospect and Rozelle).

The Sydney CBD station was the longest established station, with over 20 years of data and was the only station where high levels of CO were detected. It was located on George Street at a height just above that of bus and truck exhaust pipes and within an urban canyon typified by poor dispersion. Thus, the station was considered a peak site, likely to record the greatest concentrations of CO in the Sydney region. It was closed in 2004 following six years without recording an exceedance.

During the 1980s, CO concentrations in the CBD exceeded the standard on up to 109 days per year and the maximum level of 26.7 parts per million (ppm) was almost three times the standard.

Since the introduction of unleaded petrol and catalytic converters in 1985, peak CO levels in the CBD have plummeted. The last exceedance of the CO standard in NSW was recorded there in 1998, and since 2002, maximum 8-hour concentrations have been half the standard.

Apart from at the CBD monitoring station, levels of CO at other stations have never exceeded the standard and have fallen considerably over the past 13 years. The maximum recorded values in these areas are now typically less than 30% of the standard.

The National Environment Protection Measure for Ambient Air Quality (Air NEPM) standard for CO is no longer exceeded anywhere within the monitoring network in NSW.

4.2 Lead

Lead was measured at three sites in Sydney (the CBD, Earlwood and Rozelle) for over 20 years, until 2004. DECC began phasing out ambient lead monitoring for the Air NEPM during 2004, and all lead monitoring ceased from 1 January 2005.

The introduction of unleaded petrol in 1985, the progressive reduction of the lead content of petrol and the subsequent ban on lead in petrol from 2002 have reduced ambient concentrations of atmospheric lead in Sydney. Lead levels today are well below the Air NEPM standard of 0.5 micrograms per cubic metre ($\mu g/m^3$). Annual averages throughout NSW are now typically less than 0.03 $\mu g/m^3$ and many 24-hour average samples are below the minimum detection limit.

4.3 Nitrogen dioxide

In Sydney, the largest source of oxides of nitrogen (NO_X) emissions is on-road vehicles, which contribute over 71% of total NO_X emissions.

NO_X has been monitored continuously in NSW since the 1970s. NO_X is currently measured at 14 sites in Sydney.

During the 1980s, exceedances of the 1-hour nitrogen dioxide (NO_2) standard were common in Sydney, particularly during winter. Since then levels have fallen substantially, and the 1-hour standard has not been exceeded in Sydney since 1998. Maximum 1-hour concentrations are now well below the standard and annual average concentrations are typically less than 50% of the standard.

NSW has met the Air NEPM goal for NO_2, which allows for one exceedance per year, since 1994. The last exceedance of the 1-hour standard was recorded during 1998. Current maximum NO_2 concentrations are well below both the 1-hour and annual standards.

NO_X emissions from motor vehicles have fallen as a result of improvements to fuel and vehicle emissions standards. Emissions of NO_X from individual motor vehicles are predicted to continue falling as stricter vehicle emissions standards are introduced. However, some of these gains are countered by the increasing number of vehicles and vehicle-kilometres travelled.

4.4 Sulfur dioxide

Sulfur dioxide (SO_2) is monitored at eight stations in the Sydney region (Bargo, Bringelly, Chullora, Macarthur, Prospect, Randwick, Richmond and Vineyard).

There has never been a recorded exceedance of the 24-hour or annual SO_2 standard in NSW. Typically, maximum 24-hour averages range between 8% and 12% of the standard, and maximum annual averages range between 5% and 10% of that standard.

In Sydney, no exceedances of the 1-hour SO_2 standard have ever been recorded. The maximum 1-hour concentrations are typically less than 20% and less than 30%, respectively, of the standard.

Historically, with the exception of stations located close to major industrial sources, SO_2 levels in NSW have been significantly below the Air NEPM standards.

SO_2 levels are well below the standards and are expected to remain low.

4.5 Fine particles

There are many sources of particles in the air, arising from both natural processes and human activity. The dominant source of PM_{10} from human activity in Sydney is industry (37%), but domestic sources and on-road mobile sources make up a greater proportion of PM_{10} emissions in Sydney than in the rest of NSW.

The annual domestic sector contribution to PM_{10} emissions in Sydney comes largely from wood heating (93%). Wood heating provides a good example of the seasonal variation in emissions. In Sydney, wood heaters account for 3% of total PM_{10} particle emissions in summer (January weekday), but 43% in winter (July weekday).

In rural areas, broadacre agricultural activities (e.g. stubble burning and cultivation) and the use of solid fuels for heating and cooking are the major anthropogenic sources of particles.

Emissions from natural events, such as bushfires and dust storms, also contribute significantly to fine particle levels in NSW. Almost 20% of PM_{10} emissions in the Sydney Greater Metropolitan Region (GMR) come from agricultural burning, bushfires, prescribed burning and windborne dust.

Particles less than 10 µm in diameter (PM_{10}) and less than 2.5 µm in diameter ($PM_{2.5}$) are measured in NSW by using tapered-element oscillating microbalance (TEOM) instruments, which provide continuous, real-time particle mass measurement.

At present there is no Australian Standard method for measuring $PM_{2.5}$. A national program, the $PM_{2.5}$ Equivalence Program, is assessing the accuracy and precision of various $PM_{2.5}$ instruments. The Air NEPM $PM_{2.5}$ advisory reporting standards of 25 and 8 µg/m3 for 24-hour and annual averages are not based on $PM_{2.5}$ data measured by TEOM instruments.

In NSW, the highest exposure to fine particles occurs during severe bushfires and dust storms. During these events, peak PM_{10} and $PM_{2.5}$ levels can greatly exceed the relevant standards or goals. These events are also responsible for the greatest spatial extent (dust storms) and longest exposure to elevated levels (severe bushfires) of fine particles in NSW.

The highest ever recorded 24-hour average PM_{10} level in NSW was 921.4 µg/m^3, recorded at Albury during the severe dust storm of 19–20 March 2003. This was an extreme event that resulted in a peak concentration more than 18 times the Air NEPM standard. This same event also resulted in the highest PM_{10} levels ever recorded in Sydney.

There is a strong seasonality to PM_{10} levels. In Sydney, the majority of exceedances occur in spring and summer (81%).

The use of solid-fuel heaters, particularly older, inefficient models, during winter can be a significant source of fine particle emissions. However, winter exceedances in Sydney occur on average less than 1 day per year.

The few exceedances of the PM_{10} standard in Sydney during winter are usually localised events. Of the ten winter exceedance days from 1994 to 2006, nine were days when an exceedance was recorded at a single monitoring station. In autumn, half of the exceedances were single-station events.

In contrast, during summer, more than two thirds of PM_{10} exceedances in Sydney are multiple-station events, indicating that these events are more likely to be widespread or regional-scale. The events may be influenced by bushfires or dust storms, or they could be indicative of secondary particles produced during the formation of photochemical smog.

Exceedances of fine particle standards are common in NSW. Exceedances of the PM_{10} standard have been recorded in all monitored regions. Levels above the $PM_{2.5}$ Air NEPM standard are regularly recorded in the GMR. Since 1994 there has been no significant improvement in fine particle levels in the GMR.

There is significant seasonality to particle levels in NSW. PM_{10} exceedances occur most often in the warmer months and days above the $PM_{2.5}$ advisory reporting standard peak in winter and summer. The $PM_{2.5}$ advisory reporting strandard are exceeded more often than the PM_{10} standard.

Although background levels of fine particles in Sydney increase during the cooler months, exceedances of fine particle standards in winter are primarily local events.

Exceedances of the PM_{10} standard are common in NSW during the warmer months. Extreme values, many times greater than the standard, have been recorded. These extreme levels are the result of natural events such as dust storms and bushfires. The severe drought conditions experienced across NSW over the past few years have contributed to an increased incidence of PM_{10} levels above the standard.

5 ASSESSMENT

5.1 Air Quality

5.1.1 Construction

Excavation of shafts (for access to tunnelling operations and to remove spoil material) is required at a number of locations at different phases throughout the proposed Project. Shaft excavations and spoil removal will involve surface earthworks and construction and materials handling activities, which have potential to generate dust emissions. However, disturbed surface areas around access shafts would be maintained to an area as small as possible and most likely between 20 m^2 and 50 m^2. Dust emissions from these areas are predicted to be negligible when managed appropriately and would have localised impacts only, if any. Exposed surface areas will be managed via dust mitigation measures such as those provided in Section 6.1.1 of this report.

Table 5.1 provides the proposed locations and estimated amounts of spoil to be removed during the Sydney CityGrid Project. Note that these items of work will be conducted in phases and mitigation measures will be focussed on each phase as it is conducted. An indicative construction program is further detailed in Appendix A.1.

Table 5.1: Locations of shafts and estimated amount of spoil material removed during the Project[a]

Description	Location of Spoil Removal	Estimated Spoil Quantity (m^3)[b]
Belmore Park Zone Substation	Bulk excavation of entire site	34,000
Stub Tunnel to CSCT	Campbell Street	963
Riley Street STSS	Bulk excavation of entire site	42,000
CECT Launch Cavern	Riley Street Site	3,000
CBD Tunnel Extension	Riley Street Site	3,543
City East Cable Tunnel	Riley Street Site	57,000
Potential Stub Tunnels (x3)	From shaft locations	5,670
Underwood St Shaft	Underwood Street (or potentially Gresham Street)	1,620
Yurong Street Shaft	Yurong St / Sir John Young Cres	3,240
City East Shaft	City East Substation Location	3,240
Surface Works (General)	Around Dalley , Bent, Bridge and Gresham Streets	3,480
Contingency	Various	3,606
	Total	**161,400**

[a] Source: pers comm J. Ardas, PlanCom Consulting Pty Ltd, 28/05/2008

[b] Allows for a 50% bulking factor.

Preparation of the site for construction of the Belmore Park Zone Substation and Riley Street Sub Transmission Switching Station (STSS) would also create disturbed surface areas with potential to cause dust emissions. However, if the construction site for the Belmore Park Zone Substation is managed using dust mitigation measures such as those provided in Section 6.1.1 of this report, it is expected to cause negligible dust impacts.

Excavation in the tunnel using a roadheader and/or a Tunnel Boring Machine (TBM) would generate dust at the working face and during handling and transport of spoil material. Both types of tunnelling machines use cutting or cooling fluid, predominantly water, which would reduce the amount of dust generated. The tunnel would be mechanically ventilated to ensure that clean air is available to workers in the tunnel. During the construction period, dust laden air from the tunnel would be treated via a filtration system to remove dust particles before the air is exhausted from the tunnel. The design of the filtration system would meet the requirements of the *Protection of the Environment Operations (Clean Air) Regulation 2002* (as amended) and the filtration system would control any dust emissions at acceptable levels.

Spoil material would be stockpiled and loaded into trucks after being removed from the tunnel via the access shafts. The majority of the spoil would be removed via the Riley Street site. It should be noted that Riley Street site is an excavated area, where the low point is approximately 10 metres deep. Loading of spoil into trucks for transport off-site will occur at the low point of the site, which will help to reduce potential dust impacts on nearby receptors. The depth of the site will help to protect the loading operations from wind and if dust emissions are generated, then a higher proportion is likely to resettle within the site than if the site was exposed. In addition, dust emissions from loading and transporting of spoil material would be minimised by adhering to management and mitigation procedures such as those outlined in Section 6.1.1 of this report.

Combustion emissions will be emitted from the construction equipment and transport vehicles used during construction. Appendix A.1 provides further detail of the indicative vehicle and construction equipment to be used, as well as the approximate number of movements for spoil transport and the proposed construction schedule. At the peak of construction activity for the Project a TBM, general delivery vehicles, spoil trucks, semi-trailers (for concrete segment delivery), grout rig, gantry crane, front-end loader, excavator, dump truck and general tools and equipment may be operating simultaneously, which could include up to 20 truck movements a day. Combustion emissions from the proposed Project activities are considered to have insignificant impact on air quality when compared to emissions from existing sources in the area such as motor vehicles on nearby roads.

The main pollutants of concern during construction activities for the proposed Project are TSP and PM_{10} from dust generating construction activities. These emissions are not expected to cause adverse impacts provided that management and mitigation practices are adhered to, as outlined in Section 6.1.1 of this report.

5.1.2 Operation

During operation, the high voltage cable tunnel would be ventilated through a tunnel air intake located near St Mary's Road (opposite the Domain) or from the Riley Street STSS and out of the existing ventilation exhaust at the City North Substation.

Air emissions during operation would be clean air and adverse air quality impacts are not expected.

5.2 Greenhouse Gas

5.2.1 Combustion

During construction, greenhouse gases will be emitted from combustion in engines of construction equipment and vehicles. When the construction phase of the Project is conducted, EnergyAustralia will be required to report these emissions under the *National Greenhouse and Energy Reporting Act 2007* if they trigger the reporting requirements.

Emission factors and equations for calculating greenhouse gas emissions from automotive fuel use are provided in the *National Greenhouse Accounts (NGA) Factors (2008)*. The activity data required is the amount of fuels used. The following fuel combustion estimates were provided by EnergyAustralia (pers comm J. Ardas, PlanCom, 02/07/08):

- During the bulk excavation approximately 300 litres of diesel per day for approximately 200 days (i.e. 60,000 litres)
- During the building works approximately 50 litres of diesel per day for approximately 560 days (i.e. 28,000 litres)

Estimated greenhouse gas emissions from the combustion of diesel in construction equipment are as follows:

- Scope 1 GHG Emissions (t) = Activity (kL) x Energy Content of Fuel (GJ/kL) x EF (kg CO_{2-e}/GJ)/1000 = (88 x 38.6 x 69.5)/1000= 236 tonnes CO_{2-e}
- Scope 3 GHG Emissions (t) = Activity (kL) x Energy Content of Fuel (GJ/t) x EF (kg CO_{2-e}/GJ) /1000 = (88 x 38.6 x 5.3)/1000= 18 tonnes CO_{2-e}

5.2.2 Insulation Gas

SF_6 gas which is contained in the gas insulated transformers and other switchgear is non-toxic and typically held in relatively small quantities within the switch room. The switchgear is very reliable equipment and therefore the risk of gas leakage is extremely low. However, should a major leak occur, gas leakage alarms and an appropriately designed ventilation system would ensure the safety of personnel. As the gas is non-toxic, there is no exposure limit.

However, due to its high global warming potential (GWP) and its long atmospheric lifetime, SF_6 gas is included in the greenhouse gases of the Kyoto protocol.

During construction of the substation there would be no SF_6 onsite. SF_6 gas would be added to equipment during the commissioning stage (under strict handling procedures) and equipment is also emptied onsite for maintenance, recycling or destruction.

Therefore, since this greenhouse gas assessment is for the Belmore Park Zone Substation only, the potential for SF_6 emissions to atmosphere are:

- As spillage during filling or maintenance of insulation gas to the transformers or other switchgear;
- As leakage during operation; or
- As spillage during decommissioning of the equipment.

Emission factors and equations for calculating greenhouse gas emissions from gas insulated switchgear and circuit breaker applications are provided in the *National Greenhouse Accounts (NGA) Factors (2008).*

Calculation of emissions from SF_6 leakage from the operation of transformers and switchgear

The Belmore Park Zone Substation will use 5 transformers (each using 1,000 kg SF_6) and 16 gas insulated circuit breakers (each using 120 kg SF_6). Therefore total amount of SF_6 in operation on site is 6,920 kg.

Applying the annual leakage rate of 0.005 (i.e. 0.5%) gives:

- An annual loss of SF_6 (kg) = 0.005 x 6,920 kg = 34.6 kg of SF_6.
- Multiplying the 34.6 kg of SF_6 by its GWP of 23,900 gives a total annual emission of approximately 827 tonnes of $CO_{2\text{-}e}$.

Emissions of any spills would be calculated using the same emission factors and equations. However, this should not be required if appropriate methods and procedures are followed to eliminate the risk of spills.

It should be noted that this assessment has identified only those emissions from the Belmore Park Zone Substation. A full environmental Life Cycle Assessment (LCA) of gas insulated switchgear would also take into account other factors such as energy losses across the network, longer operating life of gas insulated gear compared with air insulated gear as well as disposal methods and procedures of decommissioning equipment.

Literature on SF_6 emissions from the electricity transmission and distribution industry supports the idea that gas insulated switchgear has better overall environmental performance than air insulated systems, as outlined in the following extract from Bessede et al (2004).

> *[Bessede et al. (2004)] "The relative contribution of SF_6 to man-made global warming effect can be calculated by taking into account the SF_6 concentration in the atmosphere and its GWP. This value is approximately 0.1%* (from all industries)*. When searching only the SF_6 gas coming from the world electrical industry, many people estimated it at 0.012%.*
>
> *On another hand, many attempts have been done to evaluate the environmental impact of SF_6 from electrical equipment via environmental Life Cycle Assessment (LCA). For example, when considering the LCA of High Voltage Circuit Breakers, it has been proven that SF_6 losses due to leakage in service or during manufacturing and commissioning are not the major*

contributors to Global Warming. In fact, most of the global warming impact is due to the energy losses during the life of the apparatus. On a more global approach, full LCA of Medium Voltage networks has been done. For example, the impact of AIS (insulation by air) and GIS (insulation by SF_6) products included in rural or urban networks were studied. These studies showed that the total environmental impact of AIS is higher than for GIS equipment (using SF6). Moreover, it was made clear that in such networks, the switchgear represents less than 10% of the total networks Global Warming impact, which is again mostly due, to the energy losses within the network."

There is also much emphasis directed at maintenance of equipment and improving disposal methods of decommissioned equipment since leakage after disposal is considered to be by far the highest contributor to SF_6 emissions from gas insulated switchgear and transformers. These issues are highlighted by the following extracts from Weston (2007) and Bessede et al. (2006) below.

[Weston (2007)] "Any mass balance approach must consider the much higher contributions of emissions from decommissioned equipment that is no longer monitored for gas loss as with equipment in service. These emissions far exceed any estimates of industry emissions percentages based on manufacturer's leakage rates (default loss rate 0.5%). As with other pollutants, responsibility should rest with the owner of the equipment, regardless of its operational status, until such time as it has been appropriately reclaimed and recycled or destroyed and documented."

[Bessede et al. (2006)] "...some losses occur when the switchgear is filled and tested, but the primary source of SF_6 gas releases are leaks from aging SF_6 gas-insulated switchgear."

The peak industry body for the Australian electricity distribution and networks industry, Energy Networks Australia (ENA), currently estimates SF_6 emission levels for the whole Australian sector to be approximately 21.8 tonnes per annum (ENA, 2008).

5.2.3 Electricity

Electricity used to run the Belmore Park Zone Substation would be considered as Scope 2 and emissions attributable to upstream energy production are considered as Scope 3, indirect greenhouse gas emissions. Emission factors and equations for calculating greenhouse gas emissions from electricity from the grid are provided in the *National Greenhouse Accounts (NGA) Factors (2008).* Note that transmission and distribution losses are reported by energy distributors elsewhere as Scope 2 emissions.

The estimated annual electricity consumption for Belmore Park is 14,000 kWh (pers comm J. Ardas, PlanCom, 02/07/08). Therefore, estimated emissions from electricity consumption are as follows:

- Scope 2 GHG Emissions (t CO_{2-e}) = (14,000 x 0.89 / 1000 = 12.5 tonnes per annum.
- Scope 3 GHG Emissions (t CO_{2-e}) = (14,000 x 0.085 / 1000 = 1.2 tonnes per annum.

6 MITIGATION MEASURES

6.1 Air Quality

6.1.1 Construction

An indicative construction program for the Sydney CityGrid Project is provided in Appendix A.1.

It should be noted that the construction phases of the Project will be staged over a timeframe of up to 10 years and potential impacts can be appropriately managed and mitigated.

It is not expected that any significant impacts will be experienced during construction. However, the following mitigation measures should be observed during demolition and construction, in order to minimise impacts as much as possible.

Demolition

- Sheet and screen buildings with suitable material and where possible strip inside buildings before demolition begins.
- Ensure that any asbestos is removed by a specialist contractor before demolition.
- Waste or materials for recycling should be removed from site as soon as possible. If stored, techniques to avoid emissions should be employed.
- Avoid explosive blasting where possible and consider using appropriate hand or mechanical alternatives.
- Bag and remove any biological debris or damp down before demolition.

Construction

- Access to construction sites would be via existing sealed roadways and the surface of trafficked areas within sites shall be sealed with bitumen or gravel.
- Wheels of all site plant and vehicles would be cleaned so that material with potential to generate dust is not spread on surrounding roads.
- Sealed roads around construction sites would be swept to remove deposited material with potential to generate dust, if necessary.
- Water shall be used to suppress particles potentially generated during the erection of boundary fences, barriers, screens and other ancillary structures.
- Areas of disturbed soils would be minimised during the construction period.
- Water may be used to suppress dust emissions during dry windy periods (as required).
- The height from which dust generating material is dropped would be minimised.

- Loaded trucks carrying spoil shall be covered at all times.
- The cutting/grinding of materials on site shall be kept to a minimum, but if necessary equipment and techniques to minimise dust will be used.
- Earthworks will be kept damp, as required, especially during dry weather.
- The tunnelling excavation face will be kept damp, as required, to minimise dust generation.
- Spoil stockpiles will be damped as necessary.
- Longer term spoil stockpiles would be treated with surface binding agents or sealed by seeding with vegetation or covered with secured tarpaulins.
- Potentially dusty materials will be handled as little as possible.
- Exhaust emissions will not discharge straight at the ground.
- Construction plant and vehicles will be well maintained and regularly serviced. Visible smoke from plant should be avoided. Defective plant will not be used.
- Engines will be switched off when vehicles are not in use and refuelling areas will be away from areas of public access.
- Loading and unloading will take place within the site.
- All waste will be removed from site and disposed to an appropriately licensed waste facility.
- A CEMP would also be prepared for the construction phase, specifically addressing measures to be implemented to minimise off-site dust emissions.

6.1.2 Operation

There are no adverse impacts on air quality predicted due to the operation of the proposed Project. Mitigation measures for air quality during operation of electricity substations and high voltage tunnels are therefore not required. The operation of the tunnel ventilation system is unlikely to adversely affect air quality in the vicinity of the City North Substation, and as such, mitigation measures are not required.

6.2 Greenhouse Gases

Any measures to reduce fuel use or improve energy efficiency would reduce emissions of greenhouse gases due to combustion.

Options for mitigating SF_6 gas from the Belmore Park Zone Substation that are within EnergyAustralia's control are focussed on best practice monitoring of leakage during operation, maintenance and end of life dismantling procedures.

Avoiding leakages during operation requires attention to the type of gaskets used in the equipment. Leakages during operations occur as gaskets age and harden with use, suffer from chemical attack and corrode. Equipment suppliers should fully evaluate the proposed environment and assess the appropriateness of gasket types for the operating life of the gas insulated transformers and switchgear.

Methods for improving leak detection monitoring and handling of SF_6 gas during operations and maintenance would also minimise emissions.

The management of the end of life gas insulated equipment should follow industry best practice guidelines. In particular, the treatment of SF_6 gas for recycling, i.e. 'cradle to cradle', or if the contamination due to arc switching is too high, from 'cradle to grave' should be managed.

Currently there are no 'whole of industry' best practice guidelines for SF_6 management within the Australian transmission or distribution network industry. The electricity distribution network industry via the peak body, Energy Networks Association, is currently developing a Guideline on the Management of SF_6.

The development of SF_6 management guidelines will assist the industry to reduce emissions of SF_6, by ensuring that all aspects of SF_6 management are addressed in a consistent manner by individual utilities. This will provide an opportunity for the Australian electricity industry, both through better handling practices and more reliable reporting, to reduce SF_6 emissions from the current estimated emissions level of 21.8 tonnes per annum (ENA, 2008).

If ENA decide to progress the Guideline, it could be completed in 2008.

7 CONCLUSIONS

This assessment has considered potential air quality impacts associated with EnergyAustralia's proposed Sydney CityGrid Project including a greenhouse gas assessment for the Belmore Park Zone Substation.

The main concern for air quality is the potential for emissions of dust and PM_{10} during construction. However, air quality impacts are predicted to be insignificant if best practice dust management procedures are practised. No further air quality assessment is required.

There are no predicted adverse impacts on air quality during the operation of the substations and high voltage tunnel.

There is potential for greenhouse gas emissions from the Belmore Park Zone Substation from combustion during construction and from leakage or spillage of insulating gas (used in transformers and switchgear) during operation, maintenance and decommissioning of equipment. Emissions of greenhouse gases will be minimised by adhering to industry best practice procedures for handling and disposal of the insulation gas, SF_6.

Provided that the appropriate management and mitigation measures are followed the impacts on air quality from the Project and emissions of greenhouse gases from the Belmore Park Zone Substation are considered to be acceptable.

8 REFERENCES

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Appendix A

Indicative CityGrid Project Construction Program

A.1 INDICATIVE CITYGRID PROJECT CONSTRUCTION PROGRAM

Construction Activity	Typical Equipment	Approximate Timing	Estimated Truck Movements (per day)
Establishment of Belmore Park Zone Substation	Mobile crane, trucks with work sheds, concrete trucks	Feb 2009	1-2 deliveries per day
Belmore Park Zone Substation site preparation (erect hoarding, service discon, site survey, services diversion	Saw cutting concrete, bitumen, backhoe, 10 truck, concrete truck, traffic control, air compressors, jack hammers	Mar 2009	1-2 deliveries per day plus truck movements
Belmore Park Zone Substation bulk excavation	Drill rig, trucks to remove spoil, concrete pumps, D7 bulldozer, rock saws, rock hammers, semi trailer trucks to remove spoil, rock anchor drills, shot crete	Mar 2009 – Dec 2009	1-2 deliveries per day plus peak of 20 spoil truck movements per day
Belmore Park Zone Substation construction of 13 levels combined substation and commercial site, commencement of zone development	Crane, scaffolding, concrete pumps, concrete vibrators, concrete delivery trucks, placement of steel reinforcement, builders lift, builders hoist, scabbling, air compressor, jack hammers, concrete/bitumen saw cutting	Jan 2010 – April 2010	1-2 deliveries per day plus peak of 20 spoil truck movements per day
Establishment of Riley St site and Preliminary Construction Activities	Power tools, concrete saws, rock hammers, excavator, concrete agitator and pump, delivery vehicles, crane.	Jun 2010 – Sep 2010	General deliveries of the period, approximately 1 per day.
Excavate TBM entry cavern and CBD Cable Tunnel Extension	Roadheader, gantry crane, delivery vehicles, spoil trucks, excavator, dump truck, front-end loader, power tools, ventilation fan.	Sep 2010 – Mar 2011	1-2 deliveries per day. 4-5 spoil trucks per day.
Construct lining for CBD Cable Tunnel Extension and Tunnel fitout.	Delivery vehicles, concrete agitator and pump, power tools and general equipment, ventilation fan.	Mar 2011 – May 2011	1-2 concrete deliveries per day during Apr 2011.
Mobilise and assemble TBM	TBM, gantry crane, delivery vehicles, front-end loader.	Feb 2011 – Mar 2011	Included above.
Excavate TBM Tunnel between Riley Street and City North.	TBM, general delivery vehicles, spoil trucks, semi-trailers (concrete segment delivery), grout rig, gantry crane, ventilation fan, front-end loader, excavator, dump truck, general tools and equipment.	Apr 2011 – Jun 2012	Segment Delivery – 5 trucks/day for approx 200 days. Spoil removal – 10-15 trucks/day.

Construction Activity	Typical Equipment	Approximate Timing	Estimated Truck Movements (per day)
Remove TBM backup assembly and demobilise	Gantry crane, transport vehicles, general plant and equipment.	Jul 2012	General construction traffic only.
TBM Tunnel Fitout	Delivery vehicles, power tools, gantry crane, ventilation fan, general plant and equipment.	Aug 2012 – Jul 2013	1-2 trucks every 3 days.
Services Shaft and stub tunnel (if required)	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools, excavator, front-end loader, roadheader, dump truck and crane.	Aug 2011 – Nov 2011	2-3 trucks per day for spoil removal plus general deliveries.
City East Shaft and stub tunnel (if required)	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools, excavator, front-end loader, roadheader, dump truck and crane.	Dec 2011 – Mar 2012	2-3 trucks per day for spoil removal plus general deliveries.
Dalley Street Shaft and stub tunnel.	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools, excavator, front-end loader, roadheader, dump truck and crane.	Apr 2012 – Jul 2012	2-3 trucks per day for spoil removal plus general deliveries.
General Surface Works (cable trenching around Dalley, Gresham, Bent Streets)	Excavator, spoil truck, delivery vehicles, concrete agitator and pump, asphalting.	Aug 2012 – Jan 2013	1-2 trucks / day.
Construct Riley Street Control Room and tunnel connections	Power tools, concrete agitator and pump, delivery vehicles.	Aug 2013 – Dec 2013	1-2 per day – general deliveries only.
Fitout Riley Street Control Room	Power tools, crane, delivery vehicles.	Jan 2014 – Apr 2014	1-2 per day – general deliveries only.
Reinstate Riley Street Site and Demobilise	Excavator, front-end loader, delivery vehicles, power tools.	May 2014 – Jun 2014	1 truck / day.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jun 2012 – Mar 2013	Semi trailer and crane (cable delivery) – once every 3 weeks. General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jan 2014 – Mar 2014	Semi trailer and crane (cable delivery) – once every 3 weeks. General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jan 2016 – Jun 2016	Semi trailer and crane (cable delivery) – once every 3 weeks. General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Oct 2016 – May 2016	Semi trailer and crane (cable delivery) – once every 3 weeks.

Construction Activity	Typical Equipment	Approximate Timing	Estimated Truck Movements (per day)
			General deliveries over the period.
132kV Cable Installation	Cranes, semi trailers, delivery vehicles	Jul 2016 – Jun 2018	Semi trailer and crane (cable delivery) – once every 4 weeks. General deliveries over the period.